

The “Dirty Half Dozen” - The Criteria Pollutants



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Sources of Air Pollution

- Air pollution comes from a variety of sources
 - **Stationary Sources** - factories, power plants, smelters
 - **Area Sources** - dry cleaners, degreasing operations
 - **Mobile Sources** - cars, buses, planes, trucks, trains
 - **Biogenic Sources** - windblown dust, volcanic eruptions, forests





Criteria Pollutants

- Pollution sources emit a wide variety of pollutants
 - Carbon Monoxide (CO)
 - Lead (Pb)
 - Nitrogen Dioxide (NO₂)
 - Ozone (O₃)
 - Particulate Matter (PM₁₀ and PM_{2.5})
 - Sulfur Dioxide (SO₂)





Regulatory Authority

- Clean Air Act (CAA) provides the principal framework for national, state, and local efforts to protect air quality
- Office of Air Quality Planning and Standards (OAQPS) is responsible for setting standards
- National Ambient Air Quality Standards (NAAQS)

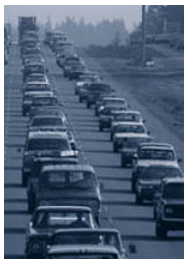




NAAQS

- Two Types of Standards
 - **Primary Standards** - provides limits to protect public health, including the health of “sensitive” populations (e.g., asthmatics, children, and the elderly)
 - **Secondary Standards** - provides limits to protect public welfare (e.g., protection against decreased visibility, damage to animals, crops, vegetation and buildings)



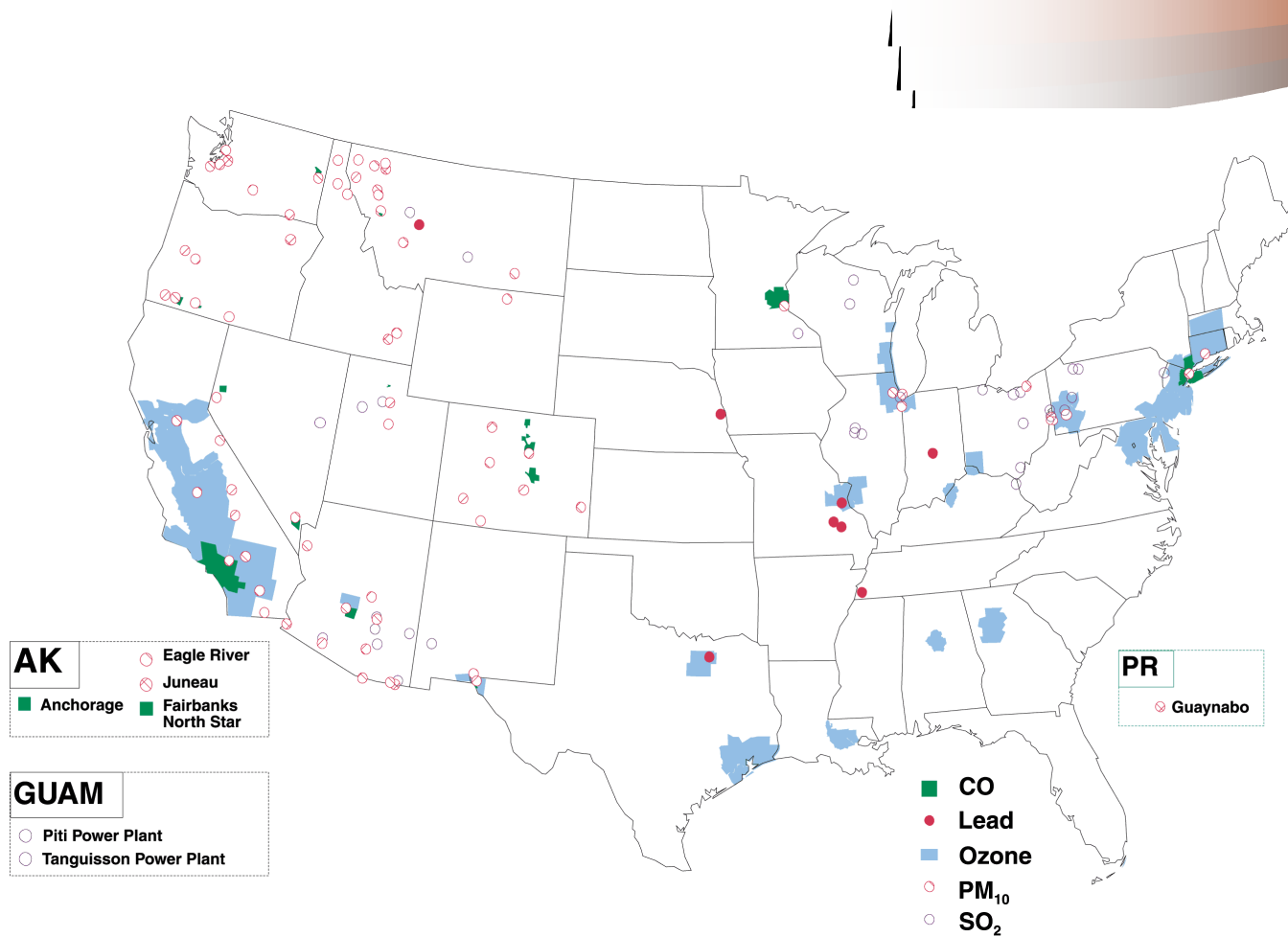


Implementation of the NAAQS

- Criteria pollutants are monitored by the EPA, as well as by national, state and local organizations
- Attainment - when a given area's monitored air quality has concentrations below the NAAQS limits
- Nonattainment - when a given area's monitored air quality exceeds the concentrations outlined by the NAAQS



Nonattainment Areas (1999)





NAAQS Limits

Carbon Monoxide (CO)

8-hr Avg	9 ppm	(10 mg/m ³)*	Primary
1-hr Avg	35 ppm	(40 mg/m ³)*	Primary

Nitrogen Dioxide (NO₂)

Ann Arith Mean	0.053 ppm	(100 µg/m ³)*	Primary/Secondary
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Ozone (O₃)

1-hr Avg	0.12 ppm	(235 µg/m ³)*	Primary/Secondary
8-hr Avg	0.08 ppm	(157 µg/m ³)*	Primary/Secondary

Lead (Pb)

Quart. Avg		1.5 µg/m ³	Primary/ Secondary
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NAAQS Limits (con't)

PM₁₀

Ann Arith			
Mean		50 $\mu\text{g}/\text{m}^3$	Primary/Secondary
24-hr Avg		150 $\mu\text{g}/\text{m}^3$	Primary/Secondary

PM_{2.5}

Ann Arith			
Mean		15 $\mu\text{g}/\text{m}^3$	Primary/Secondary
24-hr Avg		65 $\mu\text{g}/\text{m}^3$	Primary/Secondary

Sulfur Dioxide (SO₂)

Ann Arith			
Mean	0.03 ppm	(80 $\mu\text{g}/\text{m}^3$)*	Primary
24-hr Avg	0.14 ppm	(365 $\mu\text{g}/\text{m}^3$)*	Primary
3-hr Avg	0.50 ppm	(1300 $\mu\text{g}/\text{m}^3$)*	Secondary

*** - Parenthetical value is an approximately equivalent concentration**





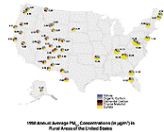
Properties of the Criteria Pollutants

Pollutant	Description	Sources	Effects
Carbon Monoxide (CO)	Colorless, odorless gas (and at much higher levels, poisonous)	Vehicle exhaust, industrial processes, wood stoves, wildfires, kerosene heaters	Headaches, reduced mental alertness, death; heart damage
Lead (Pb)	Metallic element	Vehicles (burning leaded gasoline), metal refineries & power plants	Brain & kidney damage; contaminated crops & livestock
Oxides of Nitrogen (NO_x)	Several gaseous compounds made up of nitrogen & oxygen	Vehicles, power plants (burning fossil fuels) & coal-burning stoves	Lung damage; acid rain (e.g., structural & vegetation damage; ozone & smog)



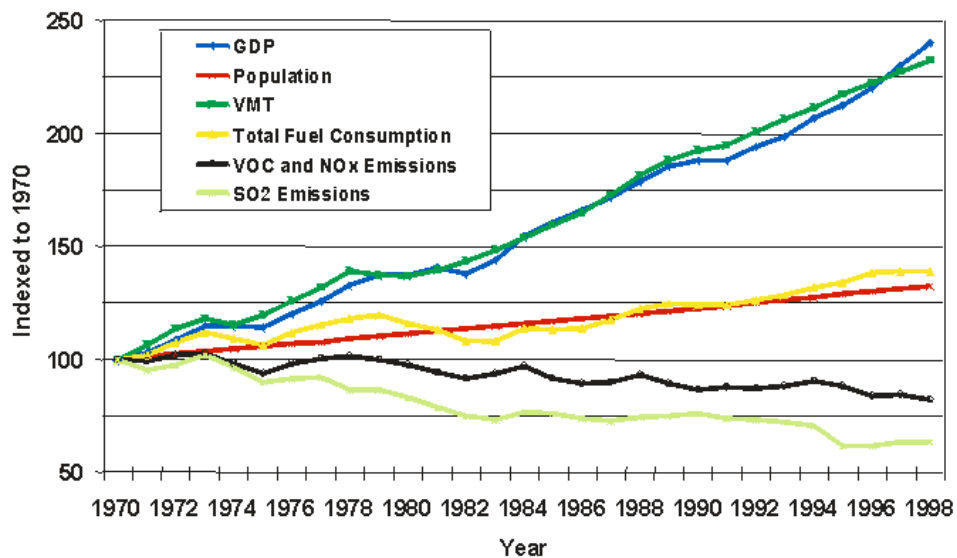
Properties of the Criteria Pollutants (con't)

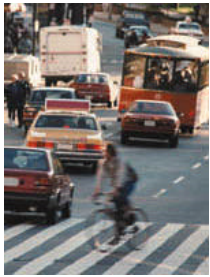
Pollutant	Description	Sources	Effects
Ozone (O ₃)	Secondarily-formed gaseous pollutant	Vehicle exhaust and certain other fumes; other photochemical reactions	Lung damage; eye irritation; respiratory problems; vegetation damage; smog
Particulate Matter (PM ₁₀ & PM _{2.5})	Very small particles of soot, or other matter, including tiny droplets of liquids	Diesel engines; power plants; windblown dust; wood stoves; other industrial processes	Lung damage; eye irritation; crop damage; visibility impairment; discoloration of buildings and statues
Sulfur Dioxide (SO ₂)	Gaseous compounds made-up of sulfur and oxygen	Coal-burning power plants and industrial sources; coal-burning stoves; refineries	Eye irritation; lung damage; kills aquatic life; acid rain; damages forests; deteriorates buildings and statues



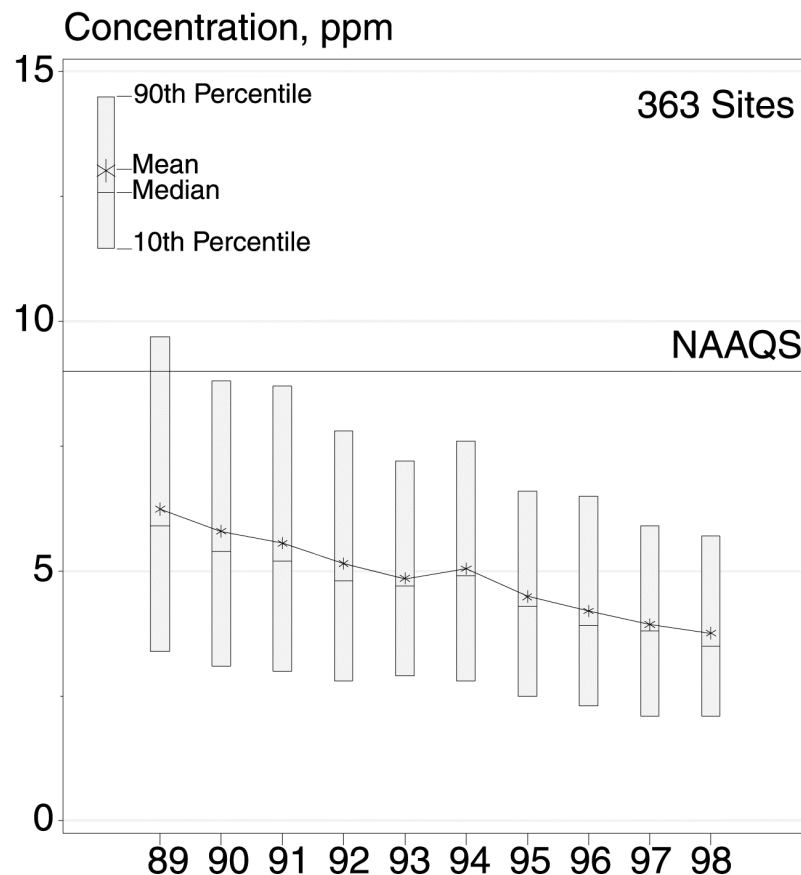
National Emission Trends

Figure 3-1. Trend in Gross Domestic Product, Population, Vehicle Miles Traveled, Total Fuel Consumption, combined VOLATILE ORGANIC COMPOUND and NITROGEN OXIDES Emissions, and SULFUR DIOXIDE Emissions, 1970 to 1998





Carbon Monoxide (CO)



**2nd Maximum Non-Overlapping
8-hour Ambient CO Concentration**

- Ambient CO concentrations decreased 39% from 1989-1999; 3% from 1997-1998
- CO emissions decreased 16% from 1989-1998; 5% from 1997-1998
- Peak CO concentrations generally occur during colder months when auto emissions are greater and nighttime atmospheric inversion conditions are more frequent

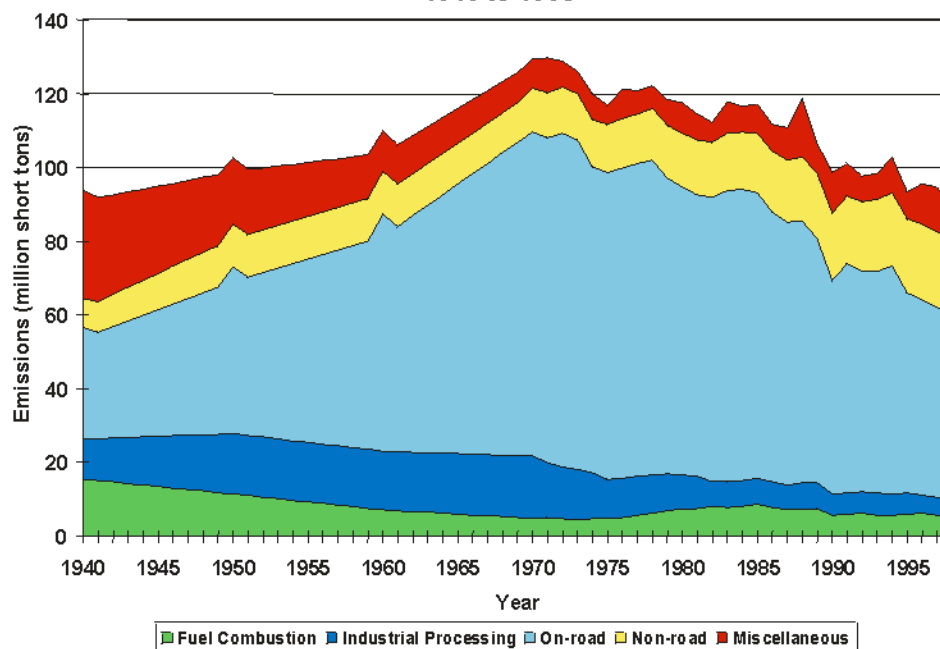




Trends in CO Emissions

3-22 ■ 3.0 Summary of National Emissions Trends

Figure 3-2. Trend in CARBON MONOXIDE Emissions, 1940 to 1998



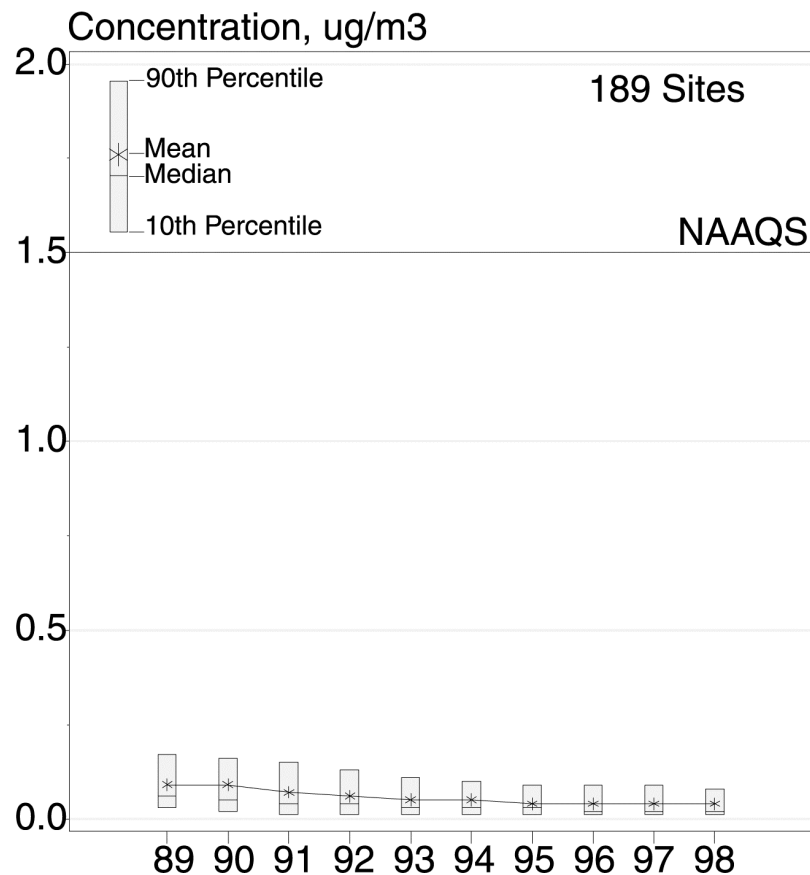
Note: Some fluctuations in the years before 1970 are the result of different methodologies

National Air Pollutant Emission Trends, 1990-1998





Lead (Pb)



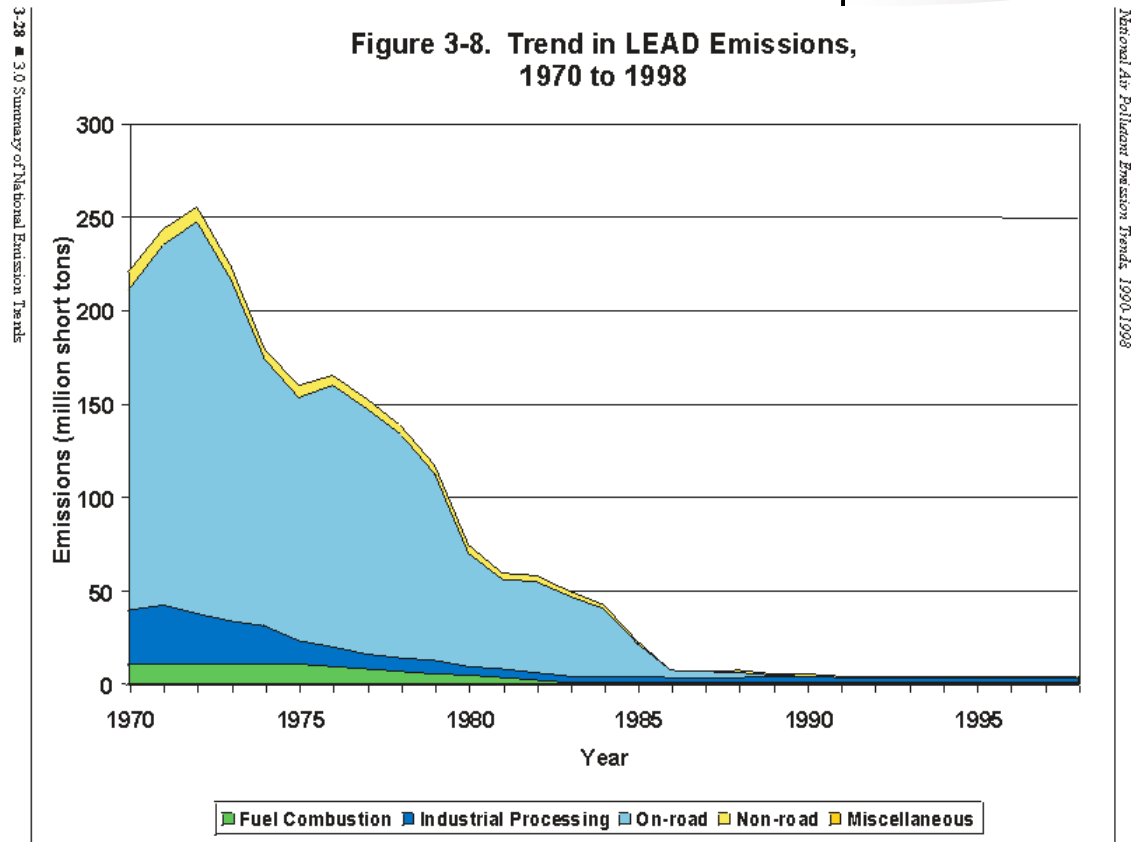
Maximum Quarterly Ambient Pb Concentrations

- Ambient Pb concentrations decreased 56% from 1989-1998; unchanged from 1997-1998
- Pb emissions decreased 27% from 1989-1998; 1% increase from 1997-1998
- 20 years ago automotive sources were the major contributor of lead emissions; today, metals processing is the dominant source



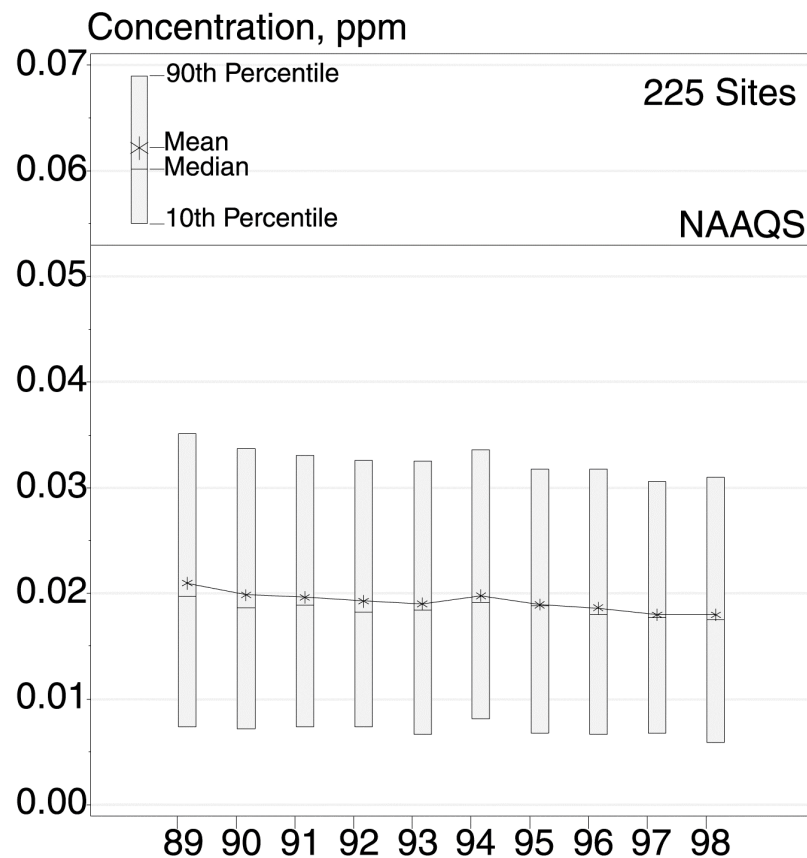


Trends in Pb Emissions





Nitrogen Dioxide (NO_2)



**Annual Mean Ambient NO_2
Concentrations**

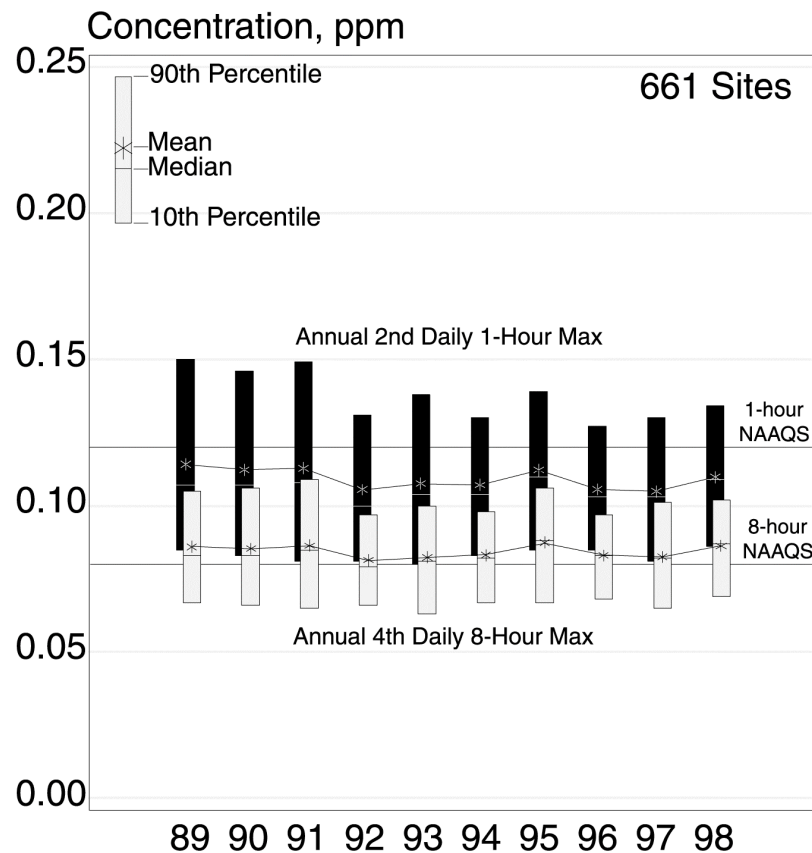
- Ambient NO_2 concentrations decreased 14% from 1989-1998; unchanged from 1997-1998
- NO_2 emissions increased 2% from 1989-1998; decreased 1% from 1997-1998
- Majority of NO_2 emissions are from high-temperature combustion processes (e.g., automobiles and power plants)







Ozone (O_3)



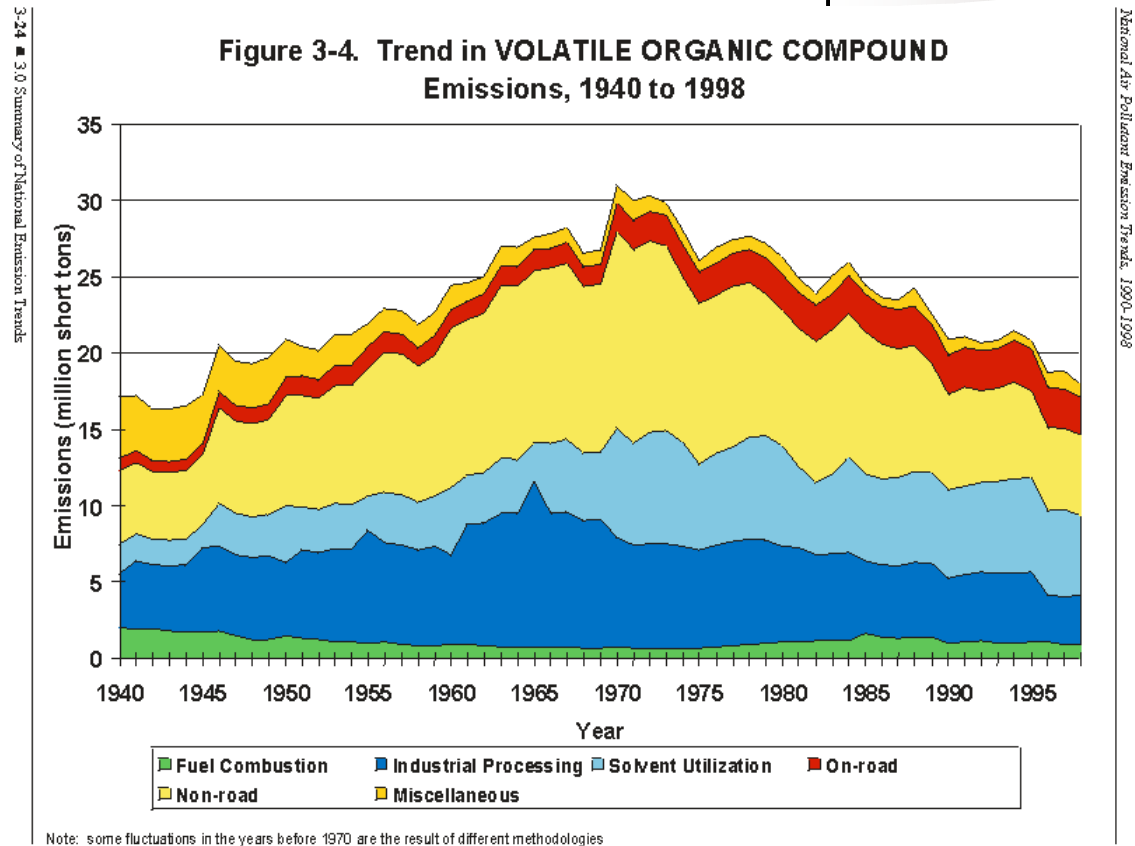
**Annual 2nd-Highest Daily Maximum 1-hour;
4th-Highest Daily 8-hour Ambient O_3 Concentrations**

- Ambient 1-hour O_3 concentrations decreased 4% from 1989-1998; increased 5% from 1997-1998
- Ambient 8-hour O_3 concentrations remained unchanged from 1989-1998; increased 4% from 1997-1998
- VOC emissions decreased 20% from 1989-1998; decreased 5% from 1997-1998
- $O_3 = \text{VOC} + \text{NO}_x + \text{Sunlight}$
- $\text{NO}_x = (\text{NO} + \text{NO}_2 + \text{other oxides of nitrogen})$



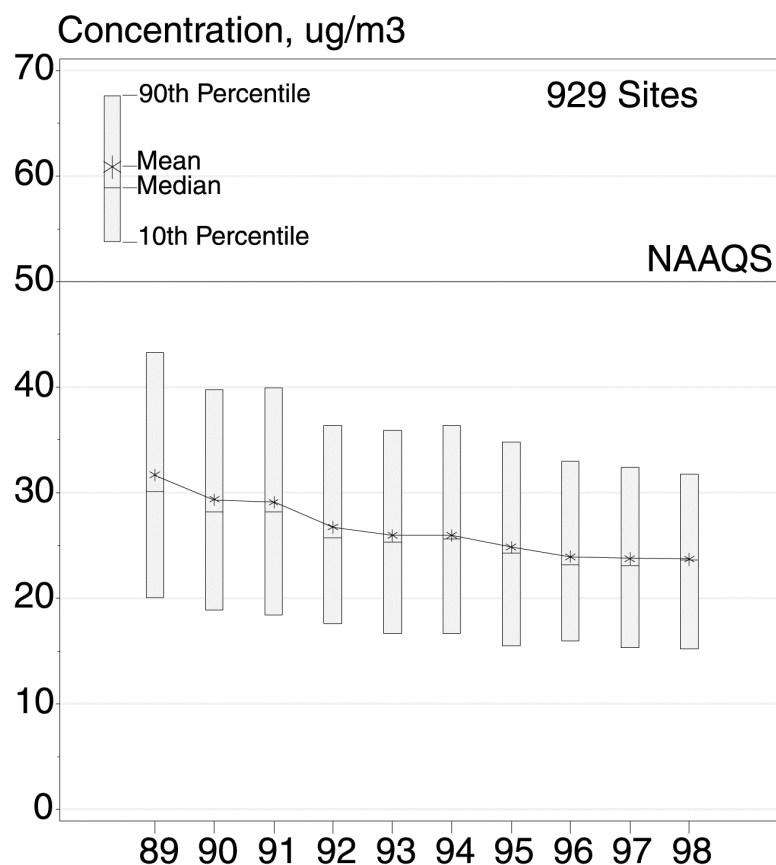


Trends in VOC Emissions





PM₁₀



**Annual Mean Ambient PM₁₀
Concentrations**

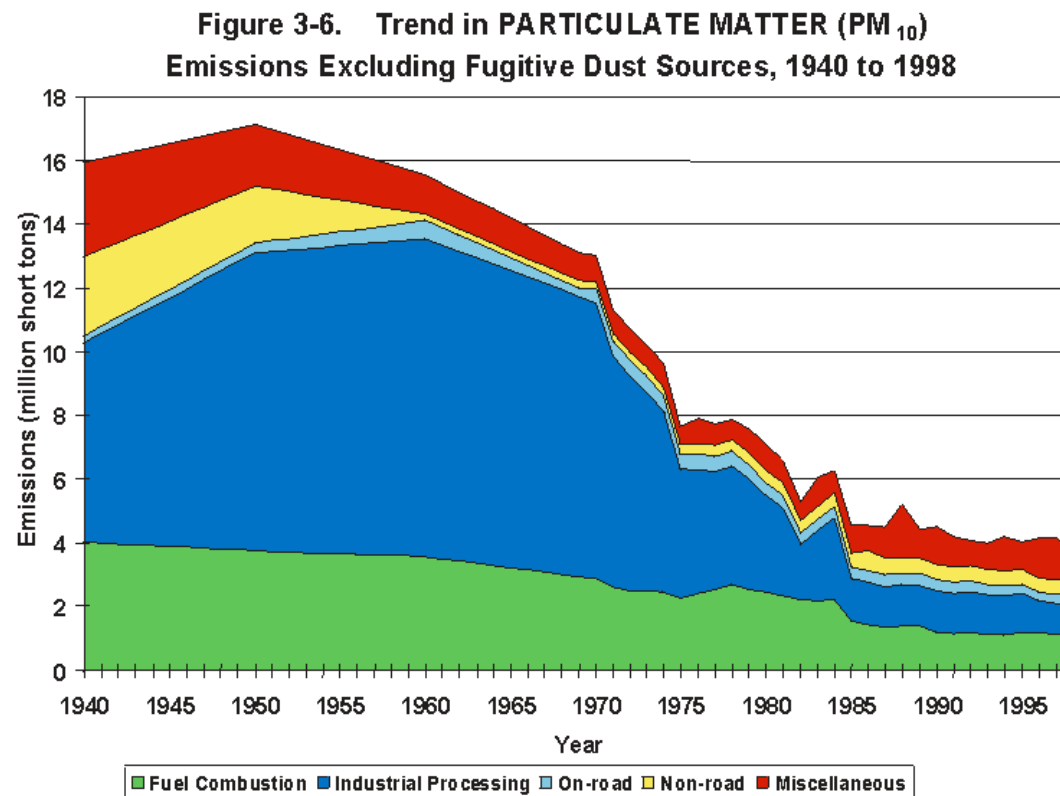
- Ambient PM₁₀ concentrations decreased 25% from 1989-1998; unchanged from 1997-1998
- PM₁₀ emissions have decreased 19% from 1989-1998; unchanged from 1997-1998
- Primary & secondary particles
- Chemical & physical properties vary by location, time of year and meteorology





Trends in PM_{10} Emissions

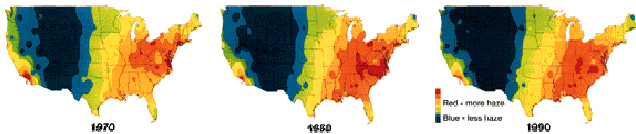
3-26 ■ 3.0 Summary of National Emission Trends



Note: Some fluctuations in the years before 1970 are the result of different methodologies

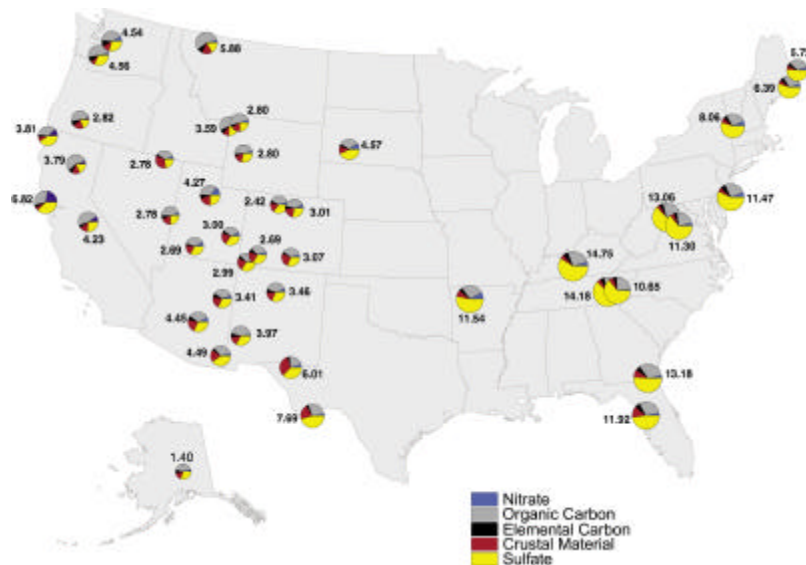
National Air Pollutant Emission Trends, 1990-1998





Maps from airport visual data show the amount of summertime haze (visibility impairment). Haze in the Eastern United States increased significantly between 1970 and 1980 and decreased slightly between 1980 and 1990.

National - $PM_{2.5}$



Annual Average 1998 $PM_{2.5}$ Ambient Concentrations ($\mu\text{g}/\text{m}^3$) at IMPROVE Sites

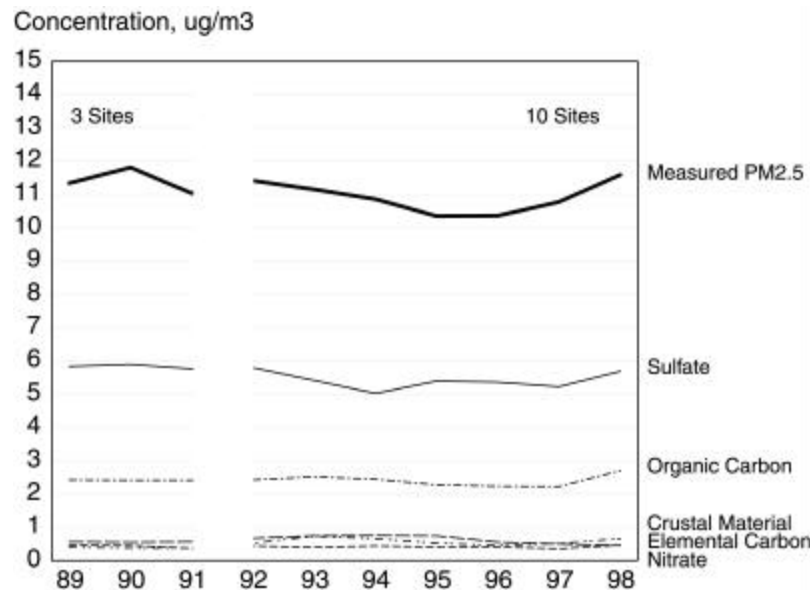
- Natural east-to-west gradation in concentrations
- Eastern sites have sulfate concentrations 4x-5x higher than western sites

	East	West
• Sulfate	56%	33%
Elemental Carbon	5%	6%
Organic Carbon	27%	36%
Nitrate	5%	8%
Crustal	7%	17%





Eastern - $PM_{2.5}$



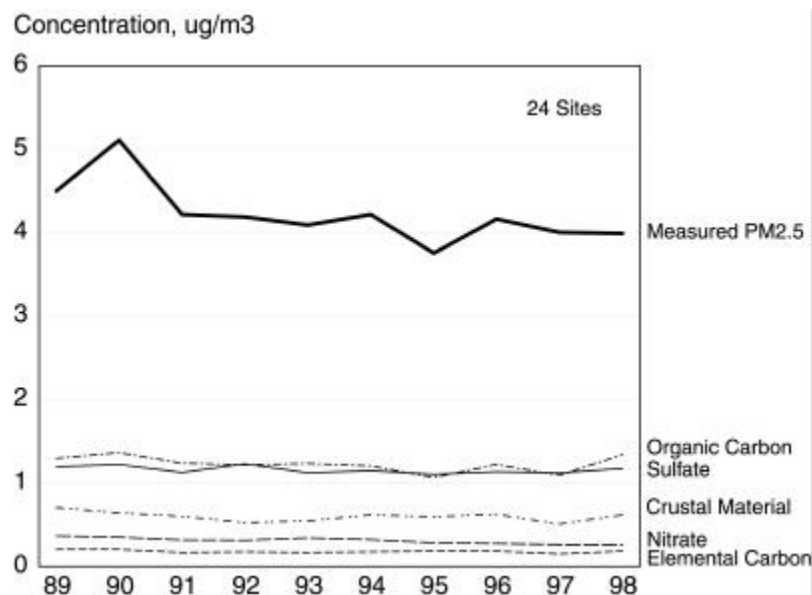
**Ambient $PM_{2.5}$ Concentrations
for Eastern U.S. IMPROVE Sites**

- Ambient $PM_{2.5}$ concentrations have decreased 9% between 1992-1995; increased 12% from 1995-1998; thus, a net 2% increase from 1992-1998
- Sulfate dominates the eastern $PM_{2.5}$ species, followed by Organic Carbon
- Nitrate, Elemental Carbon and Nitrate are approximately the same





Western - $PM_{2.5}$



**Ambient $PM_{2.5}$ Concentrations
for Western U.S. IMRPOVE Sites**

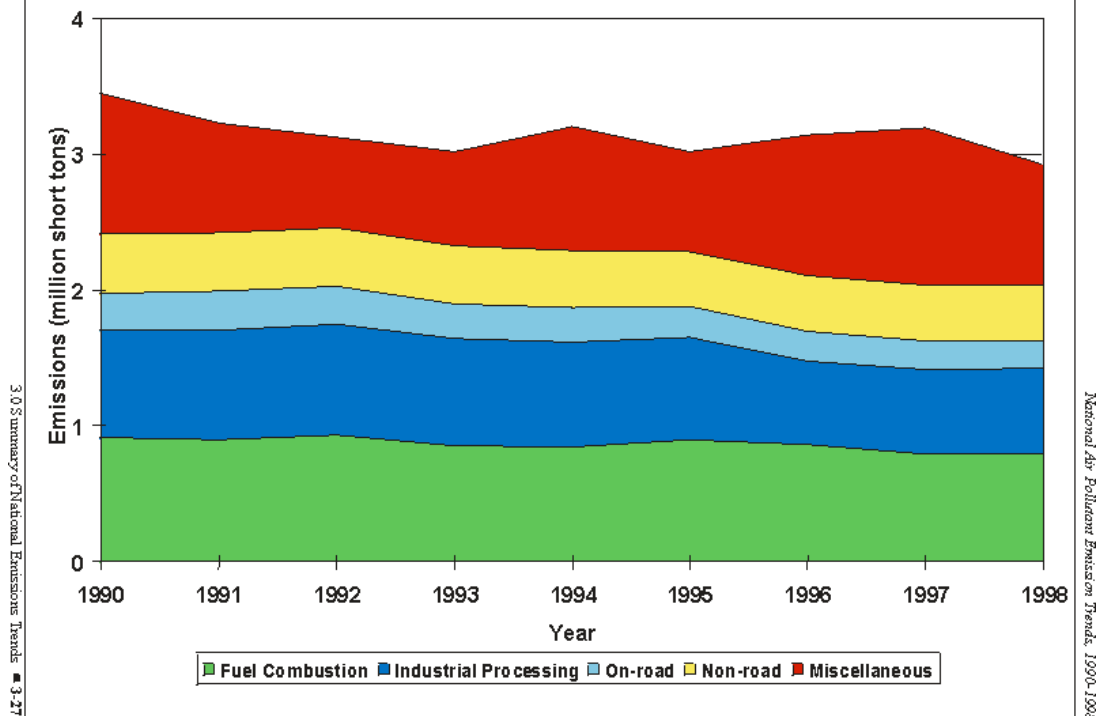
- Ambient $PM_{2.5}$ concentrations have decreased 5% from 1992-1998; and, decreased 11% over the longer period from 1989-1998
- Organic Carbon and Sulfate dominate the western $PM_{2.5}$ species, followed by Crustal Material
- Nitrate and Elemental Carbon are approximately the same





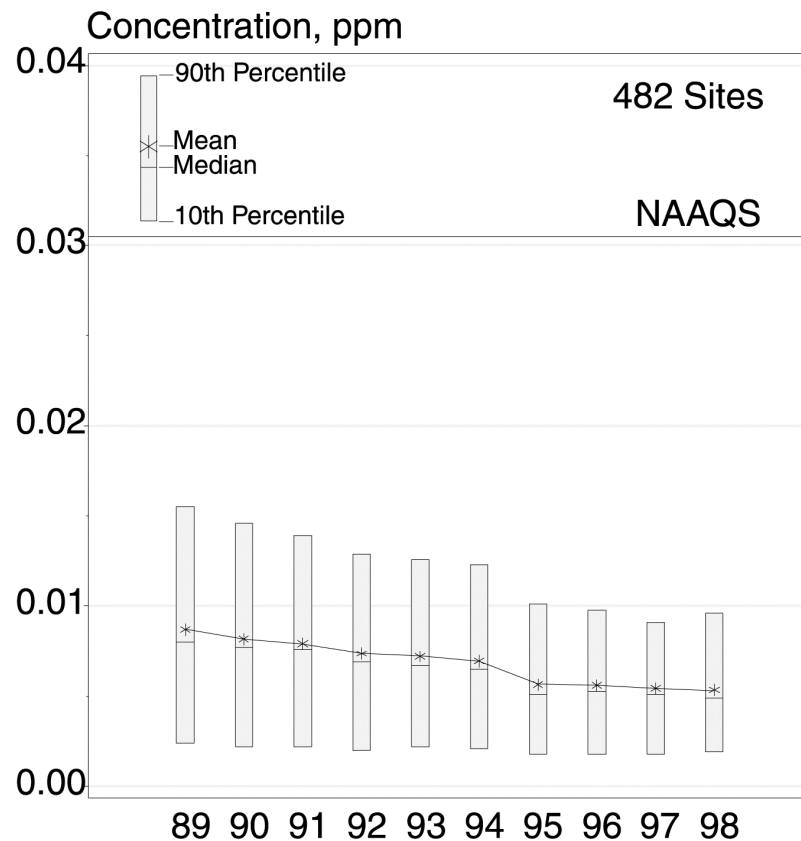
Trends in $PM_{2.5}$ Emissions

Figure 3-7. Trend in Directly Emitted PARTICULATE MATTER ($PM_{2.5}$)
Emissions Excluding Fugitive Dust Sources, 1990 to 1998





Sulfur Dioxide (SO_2)



- Ambient SO_2 concentrations decreased 39% from 1989-1998; decreased 2% from 1997-1998
- SO_2 emissions have decreased 16% from 1989-1998; unchanged from 1997-1998
- National reductions in SO_2 (emissions and ambient concentrations) from 1994-1995 are due mainly to the implementation of Phase I of the Acid Rain Program

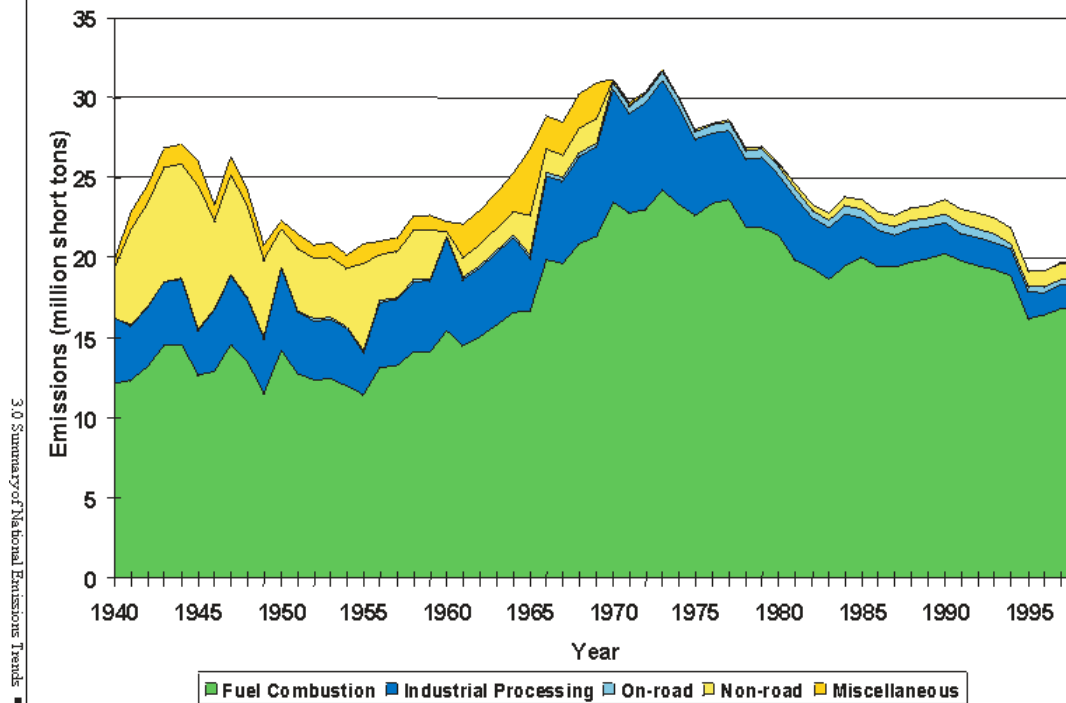
Annual Mean Ambient SO_2 Concentrations





Trends in SO_2 Emissions

Figure 3-5. Trend in SULFUR DIOXIDE Emissions, 1940 to 1998



3.0 Summary of National Emissions Trends ■ 3-25

Note: Some fluctuations in the years before 1970 are the result of different methodologies

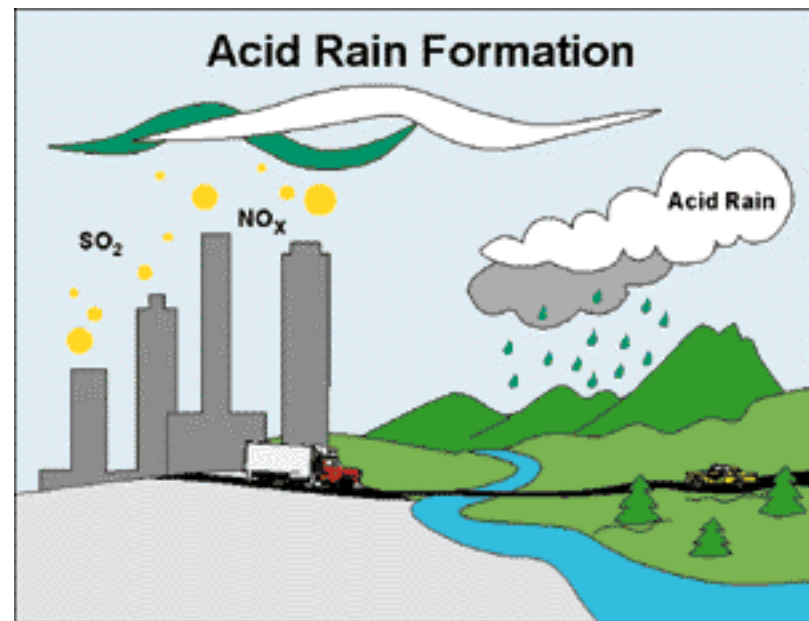
National Air Pollutant Emission Trends, 1990-1998





Other Related Issues

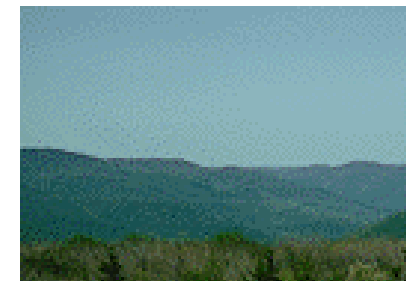
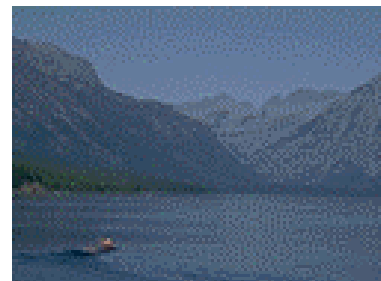
- Acidic Deposition or “Acid Rain”
 - SO_2 and NO_x emissions react in the atmosphere with water, oxygen and other oxidants to form acidic compounds
 - Wet/Dry Deposition
 - 64% SO_2 and 26% NO_x - Electric Utilities





Other Related Issues

- Regional Haze/Visibility
 - Occurs as a result of scattering and absorption of light by air pollution
 - Primary & Secondary Emissions
 - Limits distance we can see; degrades color, clarity and contrast of scenes



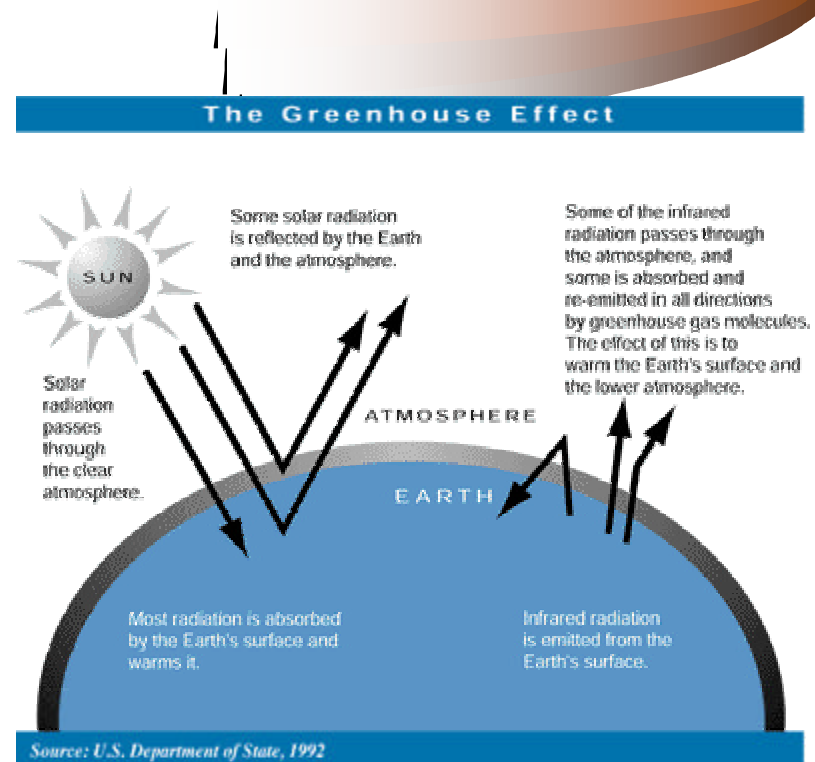
Images of Glacier National Park (left) and Dolly Sods Wilderness (right)





Other Related Issues

- Greenhouse Effect/
Global Warming
 - Earth's temperature is rising due to releases of certain gases to the atmosphere
 - Carbon Dioxide (CO₂) - 85% of U.S. greenhouse gas emissions; Methane (CH₄), second largest





Summary

- The Clean Air Act is the impetus for continued improvements in U.S. Air Quality
- Scientific and other International developments continue to effect implementation of air pollution programs at EPA
- Much progress has been made; however, there is still a great deal of work to continue
- Ultimately, air quality improvements are the result of partnerships between governments (international, federal, state and local), stakeholders (industry) and the general public

